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Riffle Beetles of Wisconsin (Coleoptera: Dryopidae, Elmidae, Lutrochidae, Psephenidae) With Notes on Distribution, Habitat, and Identification

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RIFFLE BEETLES OF WISCONSIN (COLEOPTERA: DRYOPIDAE, ELMIDAE, LUTROCHIDAE, PSEPHENIDAE) WITH NOTES ON DISTRIBUTION, HABITAT, AND IDENTIFICATION[1]

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ABSTRACT

Twenty-four species of Elmidae, three species of Psephenidae, two species of Dryopidae, and one species of Lutrochidae were represented among 33,351 riffle beetles that were identified from Wisconsin. Almost all were found in streams, but some inhabited wave-swept lake margins and spring-ponds. Adults and larvae of eight species were collected almost exclusively from submerged, decaying wood, while those of most other species inhabited rock or gravel substrates, especially in stream riffles, and only occasionally were found in wood; adults of three species of *Dubiraphia* were found also on macrophytes. The presence of *Stenelmis antennalis*, *S. fuscata*, and *S. knobeli* in Wisconsin represents significant range extensions.

Members of the coleopteran families Dryopidae, Elmidae, Lutrochidae, and Psephenidae are commonly called "riffle beetles" or "dryopoid beetles" in North America (Brown 1972, 1987a), although the latter term is no longer appropriate because Lawrence and Britton (1991) recently placed these families in the superfamily Byrrhoidea instead of Dryopoidea. Aquatic adults and larvae of riffle beetles in Wisconsin were thoroughly studied because of their importance in biological monitoring of streams and as part of an ongoing revision of the elmid genus *Stenelmis*. Both larvae and adults of Elmidae are aquatic, only adults of Dryopidae are aquatic, and in Lutrochidae and Psephenidae only larvae are aquatic. The purpose of this publication is to document the riffle beetle fauna of Wisconsin, to provide information about the occurrence of each species within the state, and to include keys and descriptions that will permit aquatic biologists to identify them.

Over the past 37 years 29,230 adult and larval riffle beetles were collected from throughout Wisconsin and identified to species, along with about 21,000 additional larvae in three genera of Elmidae, which could be identified only to genus. All are preserved in 70% ethanol and housed in the University of Wisconsin Aquatic Insect Collection. These specimens, along with those in Kurt Schmude's private collection, the University of Wisconsin Insect Research Collection, and some other collections (see acknowledgments) are the basis for this study. We found 24 species of Elmidae, three species of

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Table 1.—Numbers of Dryopidae, Elmidae, Lutrochidae, and Psephenidae collected in nine areas of Wisconsin (Fig. 1). A = adults, L = larvae.

	NW	NC	NE	WC	C	EC	SW	SC	SE	TOTAL
DRYOPIDAE adults										*1,072*
Helichus lithophilus	22	6	3	8	4	10	15	12	0	80
H. striatus	63	9	12	71	16	5	520	294	2	992
ELMIDAE adults and larvae										*31,128*
Ancyronyx variegata A	260	21	5	103	31	12	13	127	4	576
A. variegata L	15	5	2	16	2	0	8	5	2	55
Dubiraphia bivittata	4	0	0	0	3	4	4	64	27	106
D. minima	348	200	119	33	44	19	45	144	20	972
D. quadrinotata	37	93	41	8	24	27	20	98	183	531
D. robusta	32	2	3	0	2	10	0	1	0	50
D. vittata	3	99	41	13	24	192	86	799	54	1,311
Macronychus glabratus A	1521	363	339	177	483	143	370	398	193	3,987
M. glabratus L	53	12	67	5	65	2	9	58	19	290
Microcylloepus pusillus A	1	10	0	4	84	0	0	0	0	99
M. pusillus L	0	1	0	0	63	0	0	0	0	64
Optioservus fastiditus	456	1524	288	180	581	514	899	1897	376	6,715
O. trivittatus	696	467	530	101	201	21	0	0	0	2,016
Stenelmis antennalis	200	0	0	16	60	119	0	0	0	395
S. bicarinata	432	8	24	3	0	1	1	0	0	469
S. cheryl	53	138	4	7	5	0	1	0	0	208
S. crenata	1125	1994	616	715	857	928	1040	1568	882	9,725
S. decorata	1	12	4	5	6	6	553	255	0	842
S. douglasensis	0	0	0	0	10	0	1	2	2	15
S. fuscata	0	0	2	0	3	104	0	29	0	138
S. grossa	135	3	0	4	2	3	88	114	22	371
S. knobeli	0	0	0	0	0	0	246	0	0	246
S. mera	228	128	18	29	0	0	0	0	0	403
S. musgravei	0	0	0	0	0	239	657	0	111	1,007
S. quadrimaculata	111	0	0	0	0	0	0	6	0	117
S. sandersoni	202	35	28	4	47	57	0	0	0	373
S. sexlineata	0	0	0	0	0	47	0	0	0	47
LUTROCHIDAE larvae and adults										*10*
Lutrochus laticeps L	0	0	0	0	0	1	0	0	3	4
L. laticeps A	0	0	0	0	0	6	0	0	0	6
PSEPHENIDAE larvae and adults										*1,141*
Ectopria species 1 L	42	38	40	6	30	50	7	5	109	327
Ectopria species 2 L	22	10	8	8	2	0	0	0	0	50
Ectopria leechi A	0	0	0	0	0	0	0	5	0	5
Psephenus herricki L	0	12	176	0	72	315	0	8	123	706
P. herricki A	0	1	39	0	2	0	0	8	3	53

Psephenidae, two species of Dryopidae, and one species of Lutrochidae; we believe the occurrence of additional species in Wisconsin is unlikely. Riffle beetles were predominantly found in streams, but some were also collected from spring-ponds and wave-swept shallow areas of lakes. Rarely, adults of Elmidae were found in other lentic habitats; some were undoubtedly transients on dispersal flights.

Generic and species keys are provided below for all aquatic adults and identifiable aquatic larvae; they are intended for use by biologists who are familiar with riffle beetles and other aquatic beetles, at least at the family level. The keys are followed by information on the distribution, abundance, habitat, and identification of each species; distribution maps are appended. Table 1 shows the relative abundance of each species in different areas of

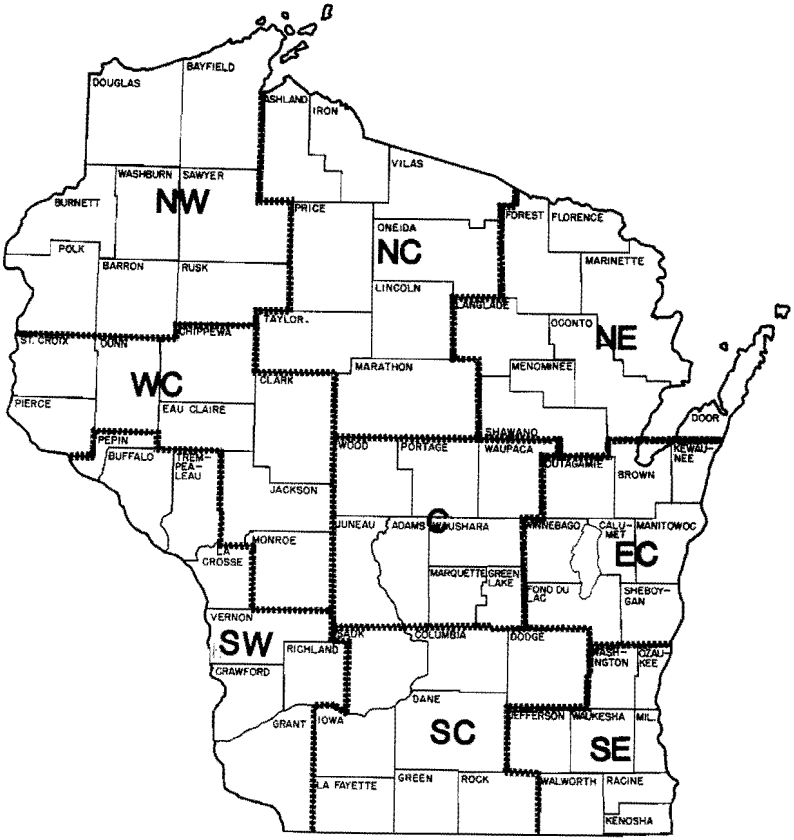


Figure 1. Map of Wisconsin showing locations of counties and the nine areas into which the state was divided (NW = northwest, NC = north-central, NE = northeast, WC = west-central, C = central, EC = east-central, SW = southwest, SC = south-central, and SE = southeast).

Wisconsin, except for larvae of *Dubiraphia*, *Optioservus*, and *Stenelmis*, most of which cannot be identified to species. Distribution of species in North America north of Mexico, along with synonymies and references to pertinent literature, appears in catalogues by Brown (1983a,b,c) and Wooldridge (1986). Keys to larvae and adults of all North American riffle beetle genera appear in Brown (1972), and White, Brigham, and Doyen (1984), with Brown also keying adults of species known at that time. Brown (1987a) also reviewed the biology of riffle beetles.

MATERIALS AND METHODS

Adults and larvae were routinely collected from rock and gravel riffles or vegetation in streams by using a kick-sampling technique and a D-frame aquatic net. They were similarly collected from shallow areas of lakes by

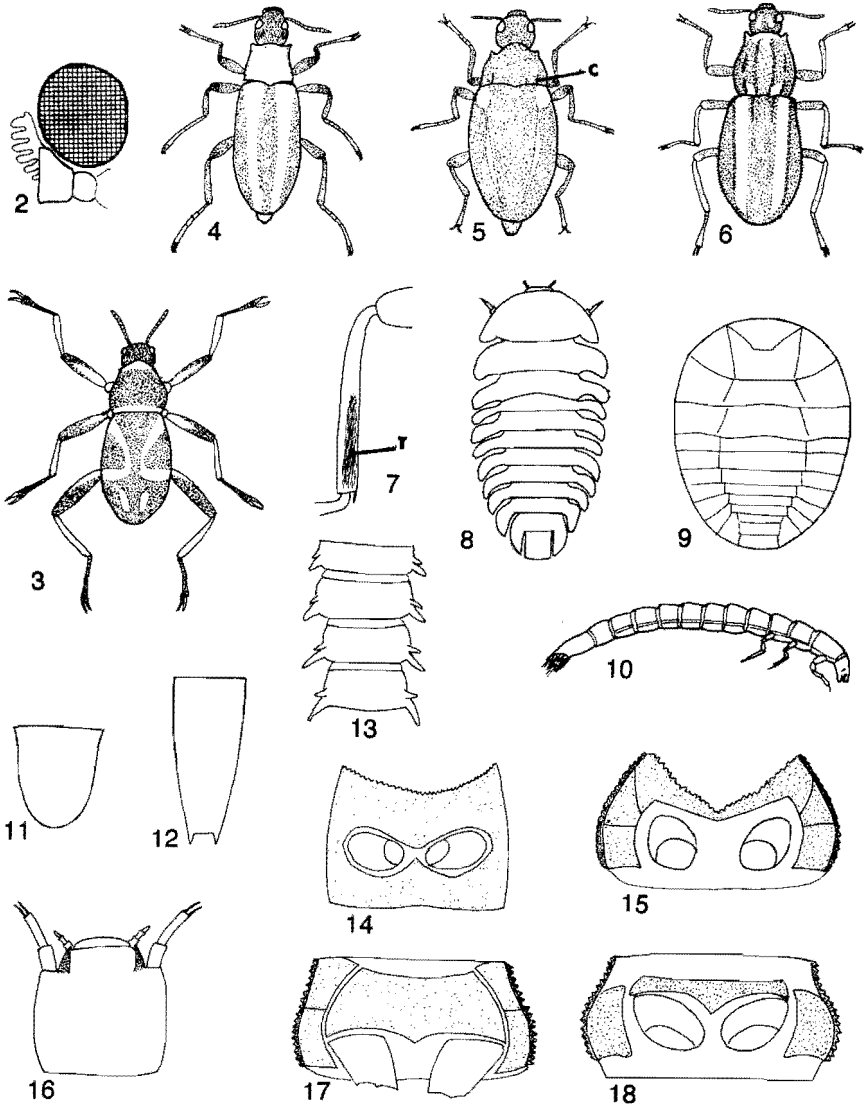
disturbing substrates and immediately sweeping a net through the water above the disturbed area. Examination and hand picking of large rocks and wood yielded numerous specimens, many of which represented rarer species. Wood-inhabiting beetles were collected as they crawled from interstices after wood was removed from the water and had begun to dry. Light traps were infrequently used to collect adults; five species of *Stenelmis* were obtained by this method. No special effort was made to collect the riparian adults of Lutrochidae or Psephenidae, although some are included in this study. No larvae of Dryopidae or terrestrial pupae of any family were collected.

Individually measured lengths of the pronotum and elytra were summed (**PE length**) and used in keys as a measure of length, which is important in identification of several species. Total length was not used because of frequent partial separation of body segments and partial retraction of the head into the thorax. Measurements were made at 72X or 144X using an ocular reticle in a Leitz dissecting microscope. A range of PE lengths is provided for all species in the keys; few individuals will be encountered that are near the extremes of the range and rarely an individual shorter or longer than the stated range may be found. In all species the average length of females was greater than that of males.

Riffle beetles, especially adults of *Stenelmis*, are often coated with dirt, sand, or mineral deposits and must be cleaned before identification, or before being pinned. We cleaned encrusted beetles with concentrated hydrochloric acid for 0.5–2.0 minutes, which either loosened or dissolved encrustations. After a thorough rinsing in alcohol, specimens were placed in a 1-dram vial of fresh alcohol, held in the water of an ultrasonic cleaner, and sonicated for 3–15 seconds. Beetles that were covered only with loose dirt or sand were not treated with acid before sonication. This method worked extremely well for beetles preserved in alcohol, and most pinned beetles on points can be held firmly (by the pin) in a wide-mouthed vial of alcohol and similarly cleaned.

KEY TO GENERA OF ADULT RIFFLE BEETLES IN WISCONSIN

1. Larger, PE length > 4.4 mm; antenna short with pectinate club (Fig 2 ..... DRYOPIDAE, *Helichus*
   Smaller, PE length < 4.1 mm; antenna slender, filiform (Figs. 3–6) ..... ELMIDAE 2
2(1). ELMIDAE – Elytra with conspicuous orange, crescent-shaped markings (Fig. 3); PE length 2.42–3.00 mm ... *Ancyronyx variegata*
   Elytra without orange, crescent-shaped markings 3
3(2). Unicolorous dark brown with no pale markings on elytra; antenna short, 7-segmented, curled under eye; legs very long (as in Fig. 3); PE length 2.85–3.63 mm ..... *Macronychus glabratus*
   Usually with pale marks or stripes on elytra (Figs. 4–6); antenna long, 11-segmented, projecting from head; legs shorter (Figs. 4–6) . . .4
4(3). Surface of pronotum smooth, except for basal carinae and/or punctures (Figs. 4–5) 5
   Surface of pronotum rough, with costae, granules, sulci, and tubercles (Fig. 6) 6
5(4). Pronotal surface smooth, except for punctures; lateral margin of pronotum smooth; elongate beetles (Fig. 4) ..... *Dubiraphia*
   Pronotal surface with basal carinae (Fig. 5); lateral margin of pronotum weakly serrate; ovate beetles (Fig. 5) ..... *Optioservus*
6(4). Larger, PE length 2.4–4.1 mm; tomentum absent from protibia .... *Stenelmis*
   Smaller, PE length 1.75–2.14 mm; tomentum present on protibia (Fig. 7). ..... *Microcylloepus pusillus*



Figures 2–18: 2. Antenna of *Helichus striatus* (anterior view). 3. *Ancyronyx variegata*. 4. *Dubiraphia vittata*. 5. *Optioservus fastiditus*. 6. *Stenelmis crenata*. 7. Protibia (posterior view) of *Microcylloepus pusillus* showing tomentum (T). 8. *Ectopria* larva (dorsal view). 9. *Psephenus herricki* larva (dorsal view). 10. *Stenelmis* larva (lateral view). 11. Last abdominal tergum of *Lutrochus laticeps*. 12. Last abdominal tergum of *Stenelmis*. 13. Abdominal terga 2–5 of *Ancyronyx variegata*. 14. Prothorax of *Stenelmis* (ventral view). 15. Prothorax of *Optioservus* (ventral view). 16. Head of *Stenelmis* (dorsal view). 17. Mesothorax of *Macronychus glabratus* (ventral view). 18. Mesothorax of *Optioservus* (ventral view).

KEY TO GENERA OF LARVAL RIFFLE BEETLES IN WISCONSIN

1. Body oval and extremely flat (Figs. 8–9); head concealed from dorsal view ..... PSEPHENIDAE 2
Body elongate, round or triangular in cross section; head exposed (Fig. 10) 3
2(1). PSEPHENIDAE – Abdominal pleura separated from each other (Fig. 8); no gills ventrally on abdominal segments 2–6 *Ectopria*
Abdominal pleura contiguous (Fig. 9); gills ventrally on abdominal segments 2–6 ..... *Psephenus herricki*
3(1). Last abdominal tergum broadly rounded (Fig. 11); one ventral ocellus below base of antenna in addition to group of 5 posterior to base of antenna ..... LUTROCHIDAE, *Lutrochus laticeps*
Last abdominal tergum apically notched (Fig 12); a group of 5 ocelli posterior to base of antenna. ..... ELMIDAE 4
4(3). ELMIDAE – Posterior angles of anterior abdominal segments produced (Fig. 13) ..... *Ancyronyx variegata*
Posterior angles of abdominal segments not produced 5
5(4). Prothorax with a posterior sternum (Fig. 14) 6
Prothorax without a posterior sternum (Fig. 15) 7
6(5). Dorsum of abdomen covered with granules; head with a distinct tooth mesad of each antenna (Fig. 16) ..... *Stenelmis*
Dorsum of abdomen with granules in longitudinal rows; head without a distinct tooth mesad of each antenna *Microcylloepus pusillus*
7(5). Last abdominal segment about 5 times longer than wide .....
..... *Dubiraphia*
Last abdominal segment less than 3 times longer than wide 8
8(7). Mesopleuron divided (Fig. 17) ..... *Macronychus glabratus*
Mesopleuron undivided (Fig. 18) ..... *Optioservus*

DRYOPIDAE ADULTS

Helichus Erichson, 1847

Adults resemble Elmidae, but are much larger and have pectinate antennae (Fig. 2). Only two species have been collected in Wisconsin, but *H. fastigiatus*, which occurs in Illinois, may also occur in the state (Musgrave 1935, Brown 1972). Larvae are riparian.

Key to Adults of *Helichus* in Wisconsin

1. Elytra completely covered with a fine, uniform, silky pubescence; scutellum projecting distinctly forward; PE length 4.76–6.08 mm ..... *lithophilus*
Silky pubescence absent from mesal third of elytra, where only coarse setae occur; scutellum only slightly arcuate anteriorly; PE length 4.48–6.33 mm ..... *striatus*

***Helichus fastigiatus* (Say, 1824)**

Distribution: It is possible, but unlikely, that this species occurs in extreme southern Wisconsin.

Identification: Adults are much broader, especially across the pronotum, than those of *H. lithophilus* and *H. striatus* of the same length. They have a forward-projecting scutellum like *H. lithophilus*, but like *H. striatus* lack pubescence on the middle of the elytra. The area of the elytra not covered by pubescence is wider than in *H. striatus*, covering the middle half instead of the

middle third; it is also distinctly sinuate laterally, not linear as in *H. striatus*. Males have a mesal pair of prominent denticles on the metacoxae.

***Helichus lithophilus* (Germar, 1824)**

Distribution and Habitat: Uncommon from northeast to southwest (Map 1). Most adults were found in decaying wood in small to large streams, although its name (stone-loving) suggests otherwise.

Identification: The dense, even pubescence that covers the beetle is distinctive.

***Helichus striatus* LeConte, 1852**

Distribution and Habitat: Common, especially in unglaciated southwest quarter and Lake Superior drainage (Map 2). Adults were found on rocks and among debris in riffles of cold to warm, small to very small streams and spring-fed brooks; they were uncommon in larger streams. Many streams in which they occurred received significant organic enrichment from agricultural sources.

Identification: The linear shiny area on the middle third of the elytra and the weakly convex anterior margin of the scutellum are diagnostic.

ELMIDAE ADULTS AND LARVAE

Ancyronyx Erichson, 1847

Only one species is known from North America.

***Ancyronyx variegata* (Germar, 1824)**

Distribution and Habitat: Fairly common, especially in western two-thirds (Map 12). Adults and larvae occurred in decaying wood, usually in larger streams and occasionally in smaller streams.

Identification: The long-legged adults are easily identified by the orange, crescent-shaped marks on the elytra (Fig. 3). Larvae have produced posterolateral angles on anterior abdominal segments (Fig. 14).

Dubiraphia Sanderson, 1954

The genus is widespread in North America, but it has not been thoroughly studied throughout its range and needs revision. Adults are recognized by their smooth pronotum, which is devoid of bumps and carinae, and by their elongate shape. Larvae are easily recognized by an elongate last abdominal segment that is about five times as long as wide.

The most recent study of adults was by Hilsenhoff (1973). In that study genitalia were slide-mounted, causing the penis ("aedeagus") to be widened, especially toward the base, and lengthened up to 7% in all species except *D. quadrinotata*. The penis, as described and illustrated below for each species, was not slide-mounted and differs from illustrations and descriptions in Hilsenhoff (1973). While the male genitalia are distinctive, size and color patterns must be relied upon to identify females. Because color patterns vary somewhat, it may not be possible to reliably identify some females that are near extremes of their size range. Larvae cannot be identified to species.

Key to Adults of *Dubiraphia* in Wisconsin

1. Large, PE length 2.85–3.19 mm; vittae broad, not constricted in basal third; penis 524–582 μm long, and at mid-length > 2 times as wide as parameres (Fig. 19) ..... *bivittata*

   Smaller, PE length < 2.75 mm; vittae often constricted in basal third; penis shorter, and at mid-length < 2 times as wide as para-

meres 2

2(1). Usually quadrinotate, if vittate, vittae darkened at basal third, except on third strial interval; penis thin, sword-shaped for entire length and gradually curved ventrally, 402–470 μm long (Fig. 20); PE length 2.06–2.75 mm, females > 2.25 mm. ... *quadrinotata*

Vittate, if vittae clouded at basal third, then PE length < 2.18 mm; penis < 375 μm long, wider in basal third, not distinctly curved ventrally. 3

3(2). Very small, PE length 1.77–2.17 mm; vittae at basal third narrow and sometimes obscure, conspicuously widened near middle to include intervals 3–7; penis narrower than parameres and nearly parallel-sided in apical two-thirds, 316–371 μm long (Fig. 21) .. *minima*

Larger, PE length in 98% of females > 2.20 mm; vittae at basal third not substantially narrower than in posterior two thirds; penis at mid-length distinctly wider than parameres and tapered in apical third 4

4(3). Robust species, width of pronotum > 0.67 mm in males and > 0.70 mm in females; penis 305–332 μm long, nearly parallel-sided in basal half, except at base (Fig. 22); PE length 2.26–2.65 mm ... . *robusta*

Usually smaller and narrower, width of pronotum infrequently > 0.67 mm in males or > 0.70 mm in females; penis 244–300 μm long, gradually tapered from base to near apex (Fig. 23); PE length 2.00–2.44 mm. ..... *vittata*

Dubiraphia bivittata **(LeConte, 1852)**

Distribution and Habitat: Uncommon, most found in southern half (Map 7). Adults inhabited plants and decaying wood in medium to large rivers and adjacent sloughs, marshes, and ponds.

Identification: The beetle's large size is distinctive, as is the very large aedeagus (Fig. 19). The smallest males are still larger than very large females of *D. robusta*, which they most closely resemble. The elytral vittae are not at all constricted in the basal third and are much broader than in adults of *D. quadrinotata*, which may be almost as long.

Dubiraphia minima **Hilsenhoff, 1973**

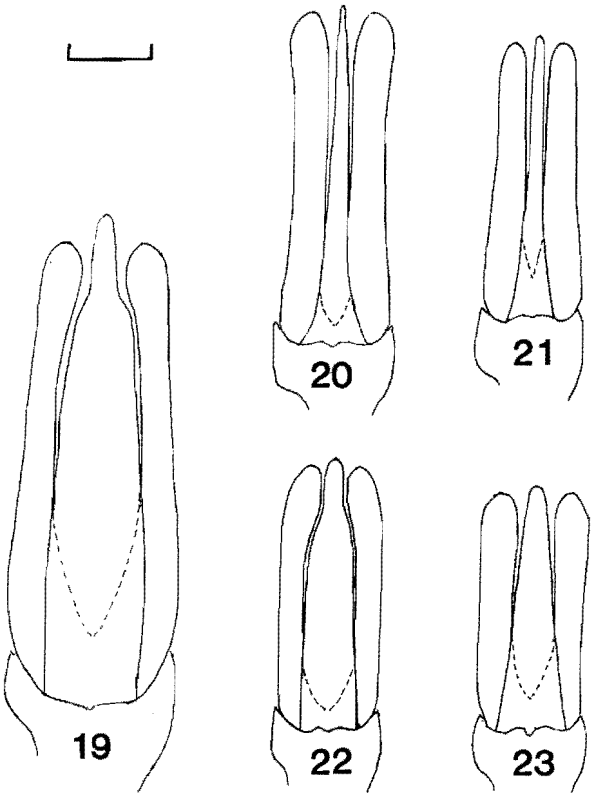
Distribution and Habitat: Common in most areas (Map 8). Adults were found on rocks, plants, roots, and decaying wood in streams of all sizes, but were more common in larger streams; occasionally they were found in wave-swept shallows of lakes.

Identification: The small size is usually distinctive. Some females are the size of very small males of *D. quadrinotata*, the only other species in which adults may have very constricted vittae basally, but the size-range of females does not overlap. Rarely, *D. vittata* are as small as *D. minima*, but in *D. vittata* the vittae are not as constricted in the basal third and the penis is shorter and much broader than in *D. minima* (Figs 21, 23). Identification of some females with a PE length of 2.1–2.2 mm may not be possible.

Dubiraphia quadrinotata **(Say, 1825)**

Distribution and Habitat: Common in most areas (Map 9). Adults occurred in rocky riffles, vegetation, and decaying wood, mostly in small to medium-sized streams; rarely, they were found in ponds.

Identification: The beetle's rather large size, along with quadrinotate elytra or greatly constricted elytral vittae, is usually distinctive. Unusually small females that are not distinctly quadrinotate could be confused with *D. minima*, but there apparently is no overlap in size. The pronotum is more convex



Figures 19–23. Genitalia of species of *Dubiraphia* showing shape of penis and parameres; scale = 100 μm. 19. *D. bivittata*. 20. *D. quadrinotata*. 21. *D. minima*. 22. *D. robusta*. 23. *D. vittata*.

anteriorly and has more distance between punctures than in other species. The relatively long, ventrally curved, sword-shaped penis of males is distinctive (Fig. 20).

***Dubiraphia robusta* Hilsenhoff, 1973**

Distribution and Habitat: Apparently rare, which may be due to inadequate sampling of lakes; most found in northwest (Map 10). Adults inhabited decaying wood in wave-swept shallows of lakes; a few were collected from larger streams.

Identification: While shorter than *D. bivittata*, adults are much longer than *D. minima* and almost always longer and broader than adults of *D.*

vittata. The broad, parallel-sided vittae immediately separate adults from those of large *D. quadrinotata*. Adults most closely resemble unusually large adults of *D. vittata*, but the pronotum is normally wider than in adults of *D. vittata* of the same length, and the vittae lack a slight constriction in the basal third that is usually found in *D. vittata*. The pronotum normally is about 6% wider anterior to the base than at the base; it is rarely more than 3% wider in *D. vittata*. The penis is always longer than in *D. vittata*, in which the penis is rather evenly tapered from the base to near the apex (Fig. 23).

***Dubiraphia vittata* (Melsheimer, 1844)**

Distribution and Habitat: Very common in eastern two-thirds (Map 11). Adults were collected mostly from rocks, travertine, vegetation, and decaying wood in streams of all sizes; rarely, they were found in ponds.

Identification: The nearly parallel-sided vittae with little constriction usually separate adults from those of *D. minima* and *D. quadrinotata*; their smaller size separates adults from those of *D. bivittata* and most *D. robusta*. In Wisconsin they are almost always larger than adults of *D. minima* of the same sex. Separation from *D. robusta* and *D. minima* is discussed under those species.

Macronychus Miller, 1806

One species occurs in North America.

***Macronychus glabratus* Say, 1825**

Distribution and habitat: Very common in most areas (Map 3). Adults and larvae were found on decaying wood and roots, and rarely on rocky substrates. They inhabited medium to large streams and wave-swept shallow areas of lakes. They were collected infrequently from small streams, and rarely from ponds.

Identification: Like *Ancyronyx variegata* (Fig 3), adults have very long legs and are readily identified by characters in the generic key. Larvae resemble larvae of *Optioservus*, but the mesopleuron is divided into two sclerites (Fig. 17).

Microcylloepus Hinton, 1935

Several subspecies of *M. pusillus* have been designated (Brown 1983a). We agree with Barr and Chapin (1988) and Shepard (1990) that subspecies are merely color morphs.

***Microcylloepus pusillus* (LeConte, 1852)**

Distribution and Habitat: Rare in central and northwest areas (Map 4). Adults and larvae inhabited rocky riffles of clear, medium-sized streams, and wood in sand-bottomed streams.

Identification: The extremely small size separates adults from all other elmids except small specimens of *Dubiraphia* and *Optioservus trivittatus*, all of which have a smooth pronotum that lacks the distinct bumps and sulci found on adults of *M. pusillus*. Two color morphs are present in Wisconsin; they key to *M. pusillus pusillus* and *M. pusillus aptus* in Brown (1972). The only apparent difference between them is the bimaculate vs. vittate color pattern on each elytron. The degree of coloration varies in adults of many other elmids, with bimaculate and vittate specimens frequently occurring within species of *Optioservus* and *Stenelmis*. Although we saw limited elytral color variation between adults within a local population, variation in adults between local populations formed a continuum that encompassed short and narrowly bimaculate to broadly vittate color patterns. Larvae resemble those of *Stenelmis*, but are readily identified by characters in the key.

Optioservus Sanderson, 1954

This genus was revised by White in 1978. Two species occur in Wisconsin; no others are likely to be found. Adults have an oval shape, and can be distinguished by their smooth pronotum with a pair of basal longitudinal carinae. Larvae lack a posterior sternum (Fig. 15) and resemble those of *Macronychus*, but have only a single mesopleural sclerite (Fig. 18). Last instar larvae of both species were associated with adults based on distribution and the significant difference in size; no larvae were reared. Only final instar larvae, which are distinguished by the presence of spiracles on the mesothorax and abdominal segments 1–8, can be identified. Since collections of adults of both species are extensive, no effort was made to find and identify final instar larvae in the collection.

Key to Adults of *Optioservus* in Wisconsin

1. Smaller, PE length 1.90–2.40 mm; a vitta on each elytron with a third vitta overlapping the elytral suture ..... *trivittatus*
   Larger, PE length 2.90–3.50 mm; each elytron vittate or bimaculate, with no vitta on elytral suture ..... *fastiditus*

Key to Final Instar Larvae of *Optioservus* in Wisconsin

1. Last abdominal tergum < 0.75 mm long ..... *trivittatus*
   Last abdominal tergum > 0.90 mm long ..... *fastiditus*

***Optioservus fastiditus* (LeConte, 1850)**

Distribution and Habitat: Abundant in almost all areas (Map 5). Adults and larvae were collected in rocky riffles of streams of all sizes, and uncommonly from submerged wood; a few were found in Lake Michigan's Green Bay.

Identification: The much larger size distinguishes adults and final instar larvae from those of *O. trivittatus*.

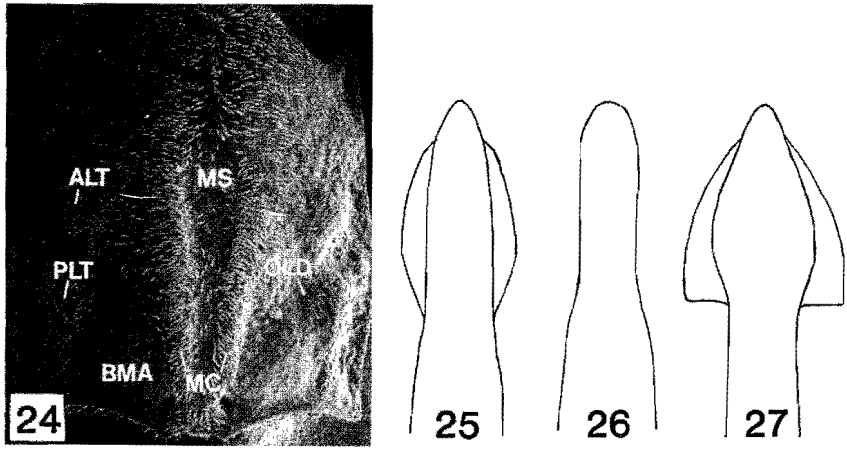
***Optioservus trivittatus* (Brown, 1930)**

Distribution and Habitat: Very common in northern third, fairly common in central third (Map 6). Adults and larvae were found in rocky riffle areas or decaying wood in streams of all sizes.

Identification: The small size and trivittate appearance of adults is diagnostic. The sutural vitta may be obscured in dark specimens, but it is revealed when an elytron is lifted above the abdomen.

Stenelmis Dufour, 1835

Sanderson revised *Stenelmis* in 1938; another revision by Kurt Schmude is in progress. Fourteen species were collected in Wisconsin. Larvae of six of them were included in Shepard's key (1980), but because larvae of six of the remaining species remain unassociated with adults, larvae cannot be reliably identified to species. Adults are readily recognized by their relatively large size and the tubercles, sulci, and costae on the pronotum. Each elytron in most species has a longitudinal pale vitta or is bimaculate. Adults of two species have an additional lateral and mesal vitta on each elytron, and adults of another species may be immaculate. Various structures on the pronotum of adults are important in identification; they are shown in Figure 24 and will be referred to in the key and frequently in the identification section under each species. A lateral process on the penis (Figs 25, 27) is helpful in identifying some species, but it often cannot be seen on specimens that were preserved in formalin, which apparently distorts this structure. Unlike other elmid genera



Figures 24–27. 24. Pronotum of *Stenelmis* showing anterolateral tubercle (ALT), posterolateral tubercle (PLT), median sulcus (MS), median costae (MC), oblique lateral depression (OLD), and basomesal area (BMA) including basomesal triangle. 25. Penis of *Stenelmis bicarinata*. 26. Penis of *S. decorata*. 27. Penis of *S. grossa*.

in which genitalia must be observed to sex adults, male *Stenelmis* in Wisconsin can be recognized by having a low, short, medial spinous ridge on the inner margin of the mesotibia. Larvae are most similar to those of *Microcylloepus*, but are readily identified by characters in the key.

Key to Adults of *Stenelmis* in Wisconsin

1. Each elytron with anterior testaceous mark overlapping umbone (anterolateral angle); each elytron bimaculate to univittate ... 2
   Anterior light mark, if present, not overlapping umbone; elytral markings variable 5
2(1). Larger, pronotal width > 0.98 mm in males and > 1.00 mm in females; elytral width ≥ 1.29 mm; pronotum wider than long, with width/length (W/L) ratio ≥ 1.05; apicoventral margin of tarsomere 5 produced into pointed process; PE length 3.05–3.63 mm. ..... *sandersoni*
   Smaller, pronotal width < than 0.98 mm in males and <1.00 mm in females; elytral width ≤ 1.31 mm; pronotal W/L ratio 0.91–1.05; apicoventral margin of tarsomere 5 truncate or slightly convex. 3
3(2). Elytron vittate, vitta confined to striae 3–5 and uniform in width; posterolateral tubercle on pronotum only slightly raised and not costiform; longer, PE length 2.85–3.39 mm ..... *cheryl*
   Elytron bimaculate, or with vitta medially clouded or widened beyond stria 3; posterolateral tubercle on pronotum variable; shorter, PE length 2.44–3.10 mm 4
4(3). Length/width (L/W) ratio of elytra > 1.85; posterolateral tubercle on pronotum only slightly raised and not costiform; PE length 2.53–3.10 mm ..... *knobeli*
   L/W ratio of elytra < 1.85; posterolateral tubercle on pronotum dis-

tinctly raised and costiform; PE length 2.44–2.91 mm. ... *mera*

5(1). Apex of antenna and/or palpi, dusky to piceous 6
Antenna and palpi completely flavous to testaceous 8

6(5). Palpi flavous to testaceous; apical antennomeres piceous, rarely dusky; PE length 2.88–3.34 mm ..... *antennalis*
Palpi fuscous to piceous; apical antennomeres testaceous to piceous 7

7(6). Larger, PE length of males 2.83–3.18 mm, females 3.04–3.26 mm; mostly lentic ..... *quadrimaculata*
Smaller, PE length of males 2.46–2.84 mm, females 2.64–2.96 mm; lotic ..... *musgravei*

8(5). Elytron trivittate, with one vitta near lateral margin (may be faint), another occupying interval 4 to stria 5, and a shorter vitta on interval 2, which may be obscure 9
Elytron univittate, bimaculate, or essentially immaculate 10

9(8). Legs and dorsum of pronotum densely granulate; tarsomere 5 shorter than or equal to preceding four tarsomeres combined; PE length 3.20–4.03 mm ..... *sexlineata*
Legs and dorsum of pronotum apparently without granules; tarsomere 5 distinctly longer than preceding four tarsomeres combined; PE length 3.25–3.71 mm ..... *douglasensis*

10(8). Tarsomere 5 shorter than, equal to, or at most just barely longer than preceding four tarsomeres combined; posterolateral tubercle on pronotum prominently raised, elongate, and nearly carinate; PE length 2.98–3.64 mm ..... *crenata*
Tarsomere 5 distinctly longer than preceding four tarsomeres combined; posterolateral tubercle on pronotum weakly raised and at most barely costiform 11

11(10). Larger, PE length of males 3.56–3.84 mm, females 3.60–3.99 mm; elytron very narrow and confined to interval 5 (sometimes also part of 4). ..... *fuscata*
Smaller, PE length of males 3.00–3.54 mm, females 2.88–3.73 mm; elytron vittate, infrequently bimaculate, with markings wider 12

12(11). L/W ratio of elytra $\leq$ 1.87; elytron most often with medially narrowed vitta, less frequently bimaculate or with vitta uniform in width; pronotum relatively convex and smooth with weakly raised median costae and tubercles, a very shallow median sulcus and weak oblique lateral depressions; pronotal granules numerous, evenly distributed, and at least as large as largest femoral granules; penis with an arcuate lateral process (Fig. 25); PE length of males 3.06–3.40 mm, females 3.14–3.61 mm ..... *bicarinata*
L/W ratio of elytra $\geq$ 1.82; combination of other characters not as above 13

13(12). Smaller, PE length of males 3.00–3.24 mm, females 3.11–3.49 mm; elytral width 1.05–1.24 mm; interocular width 0.31–0.39 mm; pronotal granules larger on basomesal area and clustered in females, with most separated by less than twice their diameter; penis without a lateral process (Fig. 26) ..... *decorata*
Larger, PE length of males 3.11–3.54 mm, females 3.25–3.73 mm; elytral width 1.16–1.38 mm; interocular width 0.36–0.44 mm; pronotal granules on basomesal area small, evenly scattered, with most separated by more than three times their diameter; penis with a subangulate lateral process giving it an arrow-shaped appearance (Fig. 27) ..... *grossa*

***Stenelmis antennalis* Sanderson, 1938**

Distribution and Habitat: Fairly common in northwest area and central third (Map 13). Previously reported only from South Carolina to Louisiana (Sanderson 1938, Brown 1983a, Barr and Chapin 1988). Adults were found exclusively on decaying wood in sandy, warm rivers of medium to large size.

Identification: Adults have a distinctive combination of piceous terminal antennomeres, testaceous palpi, and quadrimaculate elytra (each elytron narrowly vittate in some individuals). Our collections represent a considerable range extension, but based on comparison with the holotype and southern specimens, including some from Arkansas and Missouri (unpublished records), along with the similarity of habitats, we conclude that specimens from Wisconsin and the southern United States are conspecific.

***Stenelmis bicarinata* LeConte, 1852**

Distribution and Habitat: Fairly common in northern half, especially in northwest area (Map 14). Adults occurred mostly on submerged wood, but were also collected in rocky riffles and runs of moderately warm, medium to large rivers.

Identification: Schmude and Hilsenhoff (1991) recently clarified the status of this species. Adults are most similar to those of *S. decorata* and *S. grossa*, but are more ovate and have an elytral L/W ratio of 1.64–1.87; in *S. decorata* this ratio is 1.87–2.09 and in *S. grossa* it is 1.82–1.96. Elytral vittae are between interval 4 and stria 5 anteriorly and posteriorly, but are narrower medially (interval 5) in most specimens; some beetles appear quadrimaculate while a few have vittae that are uniform in width. The pronotum is more convex than in *S. decorata* and *S. grossa* because the lateral tubercles and median costae are broadly and weakly raised, and the median sulcus and oblique lateral depressions are very shallow. Pronotal granules are at least as large as the largest femoral granules, and are evenly distributed over the surface. Also, the pronotum of most specimens has three dark areas that are as dark as pronotal granules, one in the median sulcus, and two basomesal triangular areas that are bordered by the median costa, lateral tubercles, and posterior margin; dark basomesal triangles do not occur on the pronotum of *S. decorata* and *S. grossa*. This species would be identified as *S. maerkelii* Motschulsky, 1854, in Sanderson (1938) and Brown (1972).

***Stenelmis cheryl* Brown, 1987**

Distribution and Habitat: Uncommon in northern half (Map 15). Adults lived in gravel to boulder riffles in fast, clear, moderately warm streams of all sizes; they rarely were collected from submerged wood.

Identification: Adults of four species found in Wisconsin have elytral markings that overlap the umbone. All adults of *S. cheryl* from Wisconsin are vittate; the vittae are uniform in width, cover striae 3–5, and overlap only the posterolateral portion of each umbone, a portion equal in width to the width of a vitta. Adults of the three other species are mostly bimaculate on each elytron, with the anterior macula overlapping a greater portion of the umbone. In Sanderson (1938) and Brown (1972) adults are referred to as *S. bicarinata* (Brown 1987b, Schmude and Hilsenhoff 1991).

***Stenelmis crenata* (Say), 1824**

Distribution and Habitat: Abundant statewide (Map 16). Adults were collected from rocky riffles and runs, wood, travertine, and debris in most streams in the state, except for those that are either very cold, very small, heavily shaded, or heavily polluted; they also occurred on these substrates in wave-swept shallow areas of lakes.

Identification: The rough and densely granulate pronotum with its deep

median sulcus, pronounced anterolateral tubercles, and elongate and nearly carinate posterolateral tubercles, is distinctive. Pale markings on each elytron vary in intensity and shape, from bimaculate to vittate. The penis has an arcuate lateral process similar to that of *S. bicarinata* (Fig. 25).

***Stenelmis decorata* Sanderson, 1938**

Distribution and Habitat: Common in south-central and southwest areas, uncommon farther north (Map 17). Adults occurred on rocks and submerged wood in medium to very large, warm, sandy streams.

Identification: Males and females are generally shorter and narrower than those of *S. bicarinata* and *S. grossa*, but some females are difficult to distinguish from those of *S. grossa*. The ratio of elytral length to width is 1.87–2.09. In females, a clustering of relatively large pronotal granules occurs basomesally on either side of the median costae; these granules are not as clustered and slightly less numerous on males. Granules in this area are more evenly distributed on adults of *S. bicarinata* and very small and sparse on adults of *S. grossa*. Elytral vittae are most often uniform in width, but some specimens have medially narrowed vittae; a few beetles appear quadrimaculate and similar to adults of *S. bicarinata*. Males are easily separated from those of *S. grossa* and *S. bicarinata* by the absence of a lateral process on the penis (Fig. 26).

***Stenelmis douglasensis* Sanderson, 1938**

Distribution and Habitat: Very rare in southern third (Map 18). Only Sanderson (1938) reported collections of this species, finding it on submerged wood in two different lakes in Michigan. We collected 15 adults, all from submerged wood in warm, medium-sized, sand-bottomed streams, and from near the mouths of small streams that empty into the lower Wisconsin River.

Identification: Adults lack the numerous granules found on legs and pronota of all other species in Wisconsin; only tiny inconspicuous granules occur on the legs. The short, mesal elytral vitta that is confined to interval 2 may be obscure.

***Stenelmis fuscata* Blatchley, 1925**

Distribution and Habitat: Uncommon in a limited area (Map 20). Previously reported only from Alabama and Florida (Sanderson 1938, Brown 1983a). Adults were found only on submerged wood in medium to very large, warm, sand-bottomed rivers.

Identification: Based on comparisons with the holotype and many specimens of *S. fuscata* from North Carolina to Texas, and from the Mississippi River drainage basin north to Iowa (unpublished records), we conclude that the distinctive adults we collected in Wisconsin are conspecific with *S. fuscata*. Adults are most similar to those of *S. bicarinata*, but size ranges of corresponding sexes are almost disjunct. Most individuals are larger than nearly all adults of other species in Wisconsin. The color pattern of each elytron as described in the key is diagnostic.

***Stenelmis grossa* Sanderson, 1938**

Distribution and Habitat: Fairly common, especially in southern third and northwest area (Map 19). Adults were collected from rocks and submerged wood in medium to large, warm, sandy rivers, and occasionally in smaller streams.

Identification: Schmude and Hilsenhoff (1991) synonymized *S. vittipennis* Zimmermann, 1869 with *S. bicarinata*, and stated that Sanderson's (1938) concept of *S. vittipennis* should be referred to as *S. grossa*. Adults are similar to those of *S. decorata* and *S. bicarinata*, but are larger and have wider elytral

vittae that are more uniform in width (L/W ratio is 1.82–1.96); quadrimaculate specimens are rare. Pronotal granules are very small, smaller than the largest femoral granules, and frequently less numerous and more scattered than on aforementioned species.

***Stenelmis knobeli* Sanderson, 1938**

Distribution and Habitat: Rare, found only in the lower Wisconsin River (Map 15). The only published records are from Arkansas (Sanderson 1938). Adults were collected from under or on sides (at the rock/substrate interface) of large sandstone rocks and slabs in fast, shallow, rocky riffles and runs at three sites in the lower Wisconsin River, a very large, warm river with a shifting sand bottom; much of the substrate at these sites was sandstone bedrock. This species was placed on the Wisconsin Department of Natural Resources' list of endangered species in 1989.

Identification: Based on comparisons with the holotype and other specimens, we conclude that Arkansas and Wisconsin beetles are conspecific. Each elytron is bimaculate to vittate, with the vitta or anterior macula overlapping the umbone. Testaceous markings extend mesally beyond stria 3 in vittate specimens. The narrow elytra ($\leq$1.08 mm wide) make adults appear much more elongate than adults of the three other species with elytral markings that overlap the umbone.

***Stenelmis mera* Sanderson, 1938**

Distribution and Habitat: Common in northern half, especially in northwest (Map 21). Adults inhabited rocks in riffle areas of fast, medium to large, clear, moderately warm streams; they rarely occurred on submerged wood.

Identification: Adults are smaller than those of *S. sandersoni* and most *S. cheryl*. Each elytron is usually bimaculate with the anterior macula covering the entire umbone; if vittate, the vitta is at least partially clouded medially. The posterolateral tubercles on the pronotum are elongate and costiform, unlike those on specimens of *S. cheryl* and *S. knobeli*, but similar to those on adults of *S. sandersoni*. Many adults have a pair of dark basomesal triangles on the pronotum (described for *S. bicarinata*), which are absent on the three aforementioned species.

***Stenelmis musgravei* Sanderson, 1938**

Distribution and Habitat: Uncommon in southeastern rivers that empty into Lake Michigan, and in the Little Platte River drainage basin (Map 21). Adults and larvae inhabited travertine on rocks in shallow, medium-sized, warm, hardwater streams. Adults were exceedingly difficult to dislodge by kick-sampling, but more than 100 individuals per rock could be obtained by picking them from drying rocks. Both larvae and adults were deep in the interstices of the hardened, microcavernous travertine.

Identification: Like adults of *S. quadrimaculata*, which occur mostly in lakes, adults of *S. musgravei* have fuscous to piceous palpi and testaceous to piceous terminal antennomeres, but they are distinctly smaller. Each elytron is bimaculate in most specimens; sometimes it is vittate. Dark basomesal triangles on the pronotum are present on many adults of this species and *S. quadrimaculata*.

***Stenelmis quadrimaculata* Horn, 1870**

Distribution and Habitat: Very rare, records from only three sites (Map 21), which may be due to inadequate sampling of lakes. An inhabitant of marl deposits in lakes (Blatchley 1910) and lake outlets; we found specimens on submerged wood and in soft marl deposits on rocks in a single northwestern lake. Other records were from Lake Mendota in Dane Co. and the "Lower Fox

River" in Winnebago Co., which is either in or associated with Little Lake Butte des Morts.

Identification: While larger than specimens of the lotic *S. musgravei*, adults are otherwise very similar. The palpi are fuscous to piceous; apical antennomeres are dusky to fuscous, or occasionally testaceous. Elytra are usually quadrimaculate, but if vittate, vittae are narrowed or clouded medially.

***Stenelmis sandersoni* Musgrave, 1940**

Distribution and Habitat: Fairly common in northern half, especially in northwest area (Map 18). Some adults were found on rocks, but most were collected from smaller substrates within fast, rocky areas of clear, moderately warm streams of variable size; they rarely occurred on submerged wood.

Identification: The large size separates adults from those of other species that have vittae or maculae that cover each umbone. The pronotum is wider than long; its surface is densely granulate and rough in appearance with a deep median sulcus, and prominent median costae and lateral tubercles. Posterolateral tubercles are distinctly elongate and costiform.

***Stenelmis sexlineata* Sanderson, 1938**

Distribution and Habitat: Very rare in east-central area (Map 18); common south of Wisconsin. We are uncertain of its habitat since only a few adults were collected from rocky riffles in Waukau Creek, a small, warm stream that becomes dry periodically.

Identification: Adults are easily identified by their short tarsomere 5, wide pronotum (W/L ratio > 1.00), and trivittate elytron; the lateral and/or mesal vitta may be obscure. A few of our specimens are the largest *Stenelmis* in the state, and among the largest reported from North America (Schmude and Brown 1991).

LUTROCHIDAE LARVAE

***Lutrochus* Erichson, 1847**

Only one species is known to occur in the northern United States.

***Lutrochus laticeps* Casey, 1893**

Distribution and Habitat: Very rare in southeast (Map 24). Larvae and adults were collected from small to large, warm, calcareous streams that contained nearly equal percentages of cobbles, pebbles, gravel, and sand. Ovipositing adults were found on submerged wood and on travertine on rocks in shallow riffles; larvae were collected from rocks.

Identification: Larvae are similar to those of Elmidae, but the last tergum is broadly rounded apically (Fig. 11). The riparian adults can be identified by using the key in Brown (1972).

PSEPHENIDAE LARVAE

***Ectopria* LeConte, 1853**

Brigham (1981) recognized adults of three species in North America, *E. leechi* Brigham, 1981, *E. nervosa* (Melsheimer, 1845), and *E. thoracica* (Ziegler, 1845). The only adults in our collection are five *E. leechi*, which were collected from Dane Co. in the early 1900's. We have not associated larvae with adults, but we recognize larvae of two species in Wisconsin and a third species from Louisiana. Based on reliable distribution records of adults of the three species (Brigham 1981, Barr and Chapin 1988, Brigham pers. comm.), we believe that only two species occur in Wisconsin. After comparing the distribution of the

two larval forms in Wisconsin with the known distribution of adults, we conclude that larvae of species 1 are probably *E. leechi* and larvae of species 2 are probably *E. nervosa*. *Ectopria thoracica* is apparently a southern and eastern species; larvae from Louisiana lack asperities (dark, dot-like elevations) and are likely this species. The riparian adults can be identified by using Brigham's key (1981).

Key to Larvae of *Ectopria* in Wisconsin

1. Numerous dark asperities on all lateral abdominal projections and between dorsal longitudinal rows of asperities; setae on posterior margin of thoracic and abdominal terga clear and inconspicuous ..... *Ectopria* species 1
   Dark asperities mostly absent from lateral abdominal projections and from between dorsal longitudinal rows of asperities; conspicuous, dark, brush-like setae arising from posterior margins of terga on thorax and abdominal segments 1–7 .... *Ectopria* species 2

***Ectopria* species 1**

Distribution and Habitat: Fairly common statewide, especially in southeastern area (Map 23). Larvae were found on cobbles and boulders in streams of all sizes and wave-swept shallows of lakes; some were found on submerged wood. Many were collected from sandy, hardwater streams where they occurred on and underneath sand and travertine deposits on rocks. Larvae of the two species were collected together in only two rivers in the northwest.

Identification: The key readily separates larvae of the two species.

***Ectopria* species 2**

Distribution and Habitat: Rare in northern half (Map 24). Larvae occurred on cobbles and boulders in medium to large streams; a few were found on submerged wood. None were collected from lakes.

Identification: Larvae are easily identified by the key.

***Psephenus* Haldeman, 1853**

Only one species occurs in eastern North America (Brown and Murvosh 1974).

***Psephenus herricki* (DeKay, 1844)**

Distribution and Habitat: Common in eastern half (Map 22). Larvae were found on cobbles and boulders in riffles and runs of streams and wave-swept shallows of lakes, including Lake Michigan's Green Bay.

Identification: Characters in the key readily separate larvae from those of *Ectopria*. The riparian adults, which enter the water to oviposit, can be identified by using the key in Brown and Murvosh (1974).

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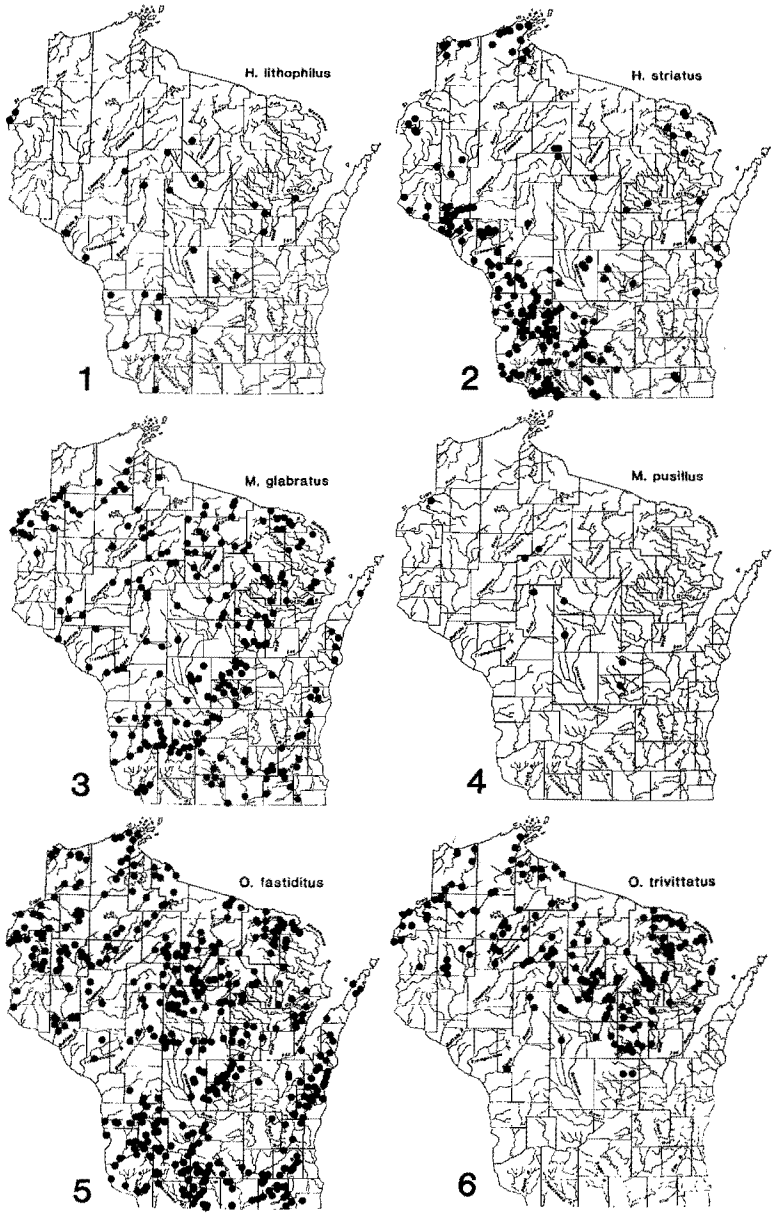
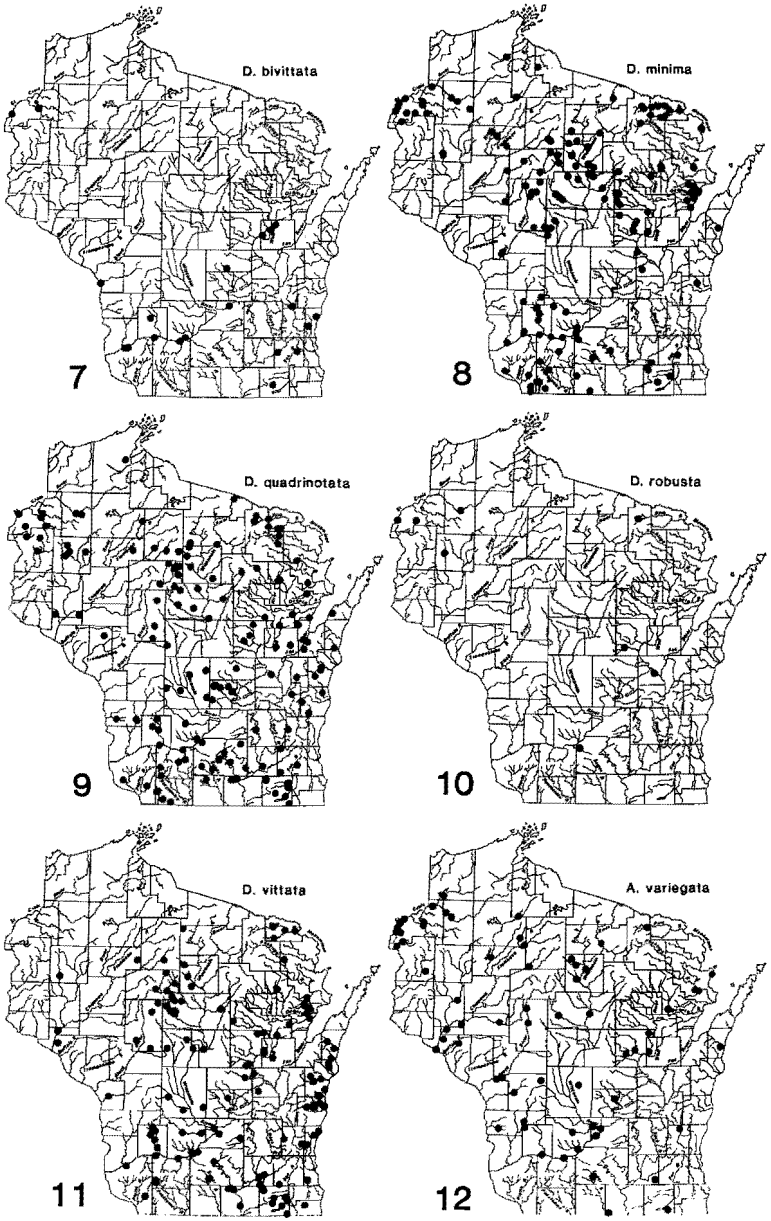
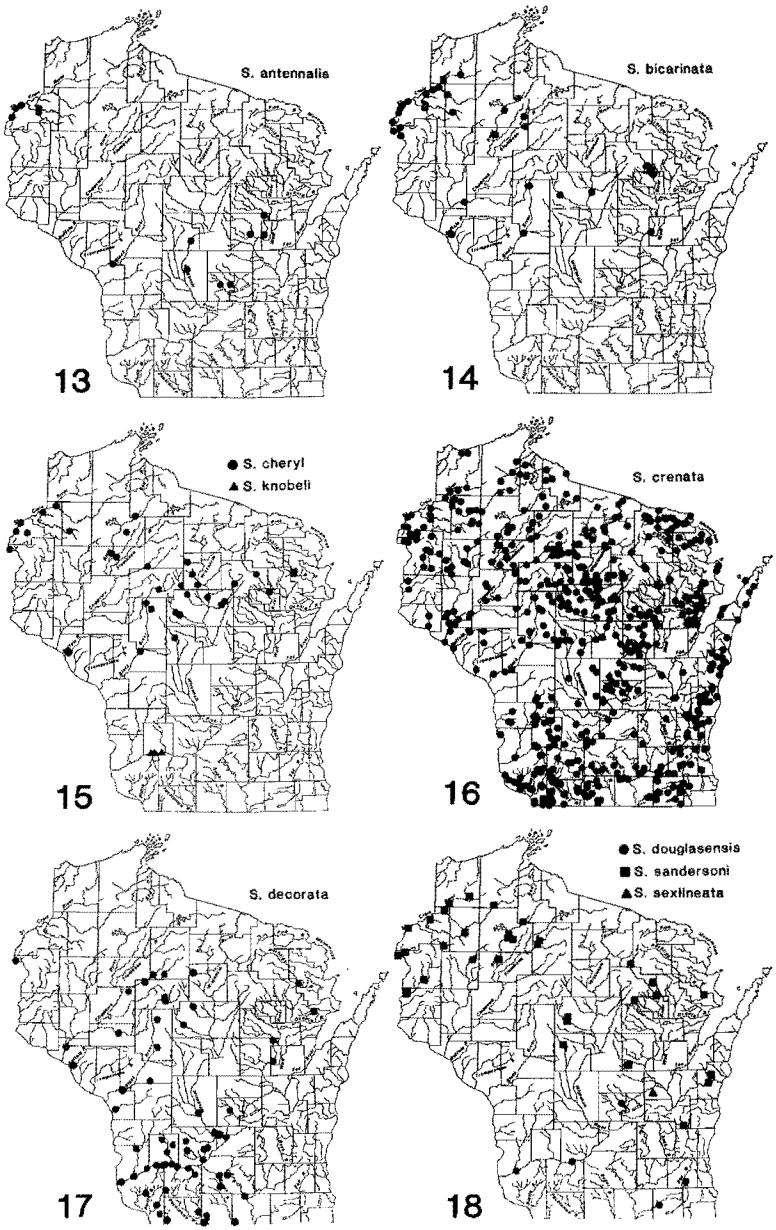


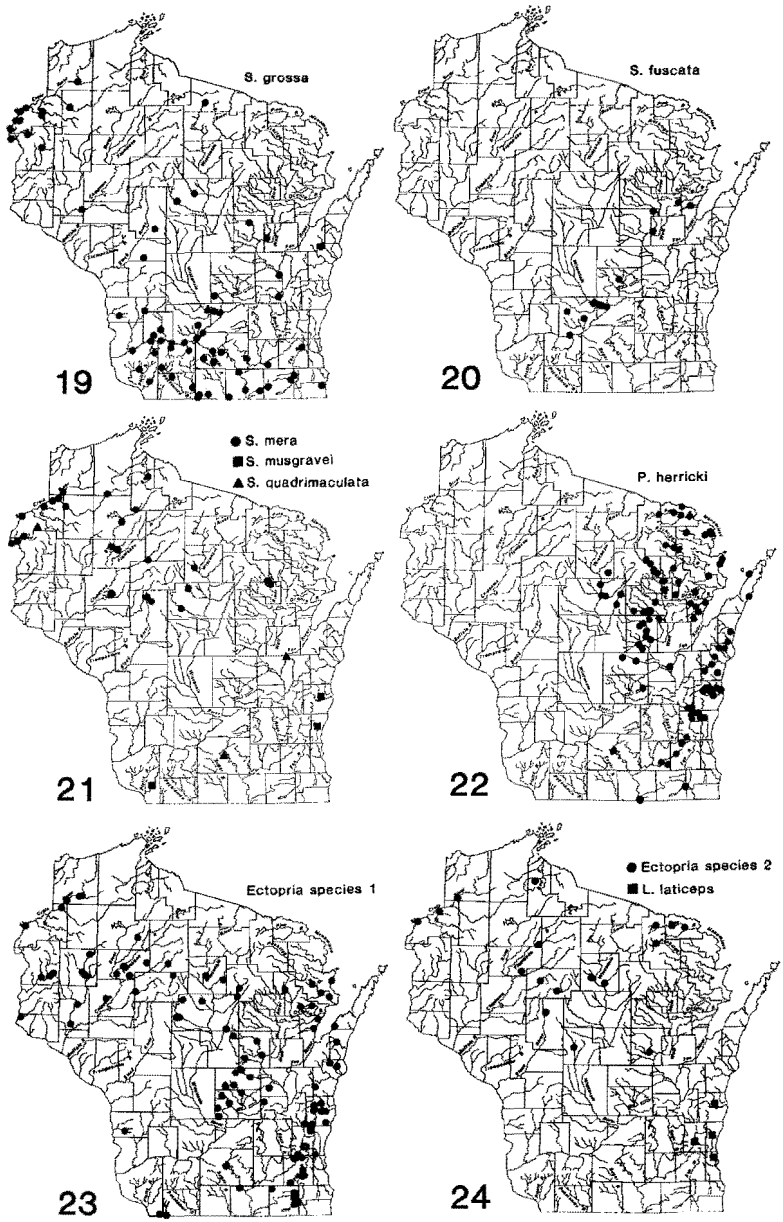
Maps 1–6. Locations of collections made in Wisconsin. 1. *Helichus lithophilus*. 2. *H. striatus*. 3. *Macronychus glabratus*. 4. *Microcylloepus pusillus*. 5. *Optioservus fastiditus*. 6. *O. trivittatus*.



Maps 7–12. Locations of collections made in Wisconsin. 7. *Dubiraphia bivittata.* 8. *D. minima.* 9. *D. quadrinotata.* 10. *D. robusta.* 11. *D. vittata.* 12. *Ancyronyx variegata.*



Maps 13–18. Locations of collections made in Wisconsin. 13. *Stenelmis antennalis*. 14. *S. bicarinata*. 15. *S. cheryl* and *S. knobeli*. 16. *S. crenata*. 17. *S. decorata*. 18. *S. douglasensis*, *S. sandersoni* and *S. sexlineata*.



Maps 19-24. Locations of collections made in Wisconsin. 19. *Stenelmis grossa*. 20. *S. fuscata*. 21. *S. mera, S. musgravei* and *S. quadrimaculata*. 22. *Psephenus herricki*. 23. *Ectopria* species 1. 24. *Ectopria* species 2 and *Lutrochus laticeps*.